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SIMPLIFIED ASSESSMENT OF CONNECTIVITY OF PHOTOVOLTAIC POWER PLANTS IN THE LOW VOLTAGE NETWORKS

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ABSTRACT

This paper deals with simplified computing of connectivity of photovoltaic power plants in the low-voltage networks, describes possibilities of the connection of one or more different power plants in three, two, or one phase. In our case it is computed the voltage change from all the PVP connected to the same network. The results from this paper can help to faster assessment of possibilities of connection the new renewable energy sources.

Keywords

Photovoltaic power plant; PVP; Photovoltaic power station; Accumulation of PVP in LV network; Possibilities of connection; Renewable energy sources in distribution network;

1. INTRODUCTION

Photovoltaic power plant connected into a distribution network can adversely affect the quality of delivered energy. Detailed calculation of the connectivity of renewable energy sources is quite complex and depends on many parameters. But the question is whether some of these parameters can be neglected to simplify the calculation. Motivation is a large number of requests for connection of new PVP, their cumulating in low-voltage networks and the need for their solution within the statutory term.

2. FACTS AND TECHNICAL DESCRIPTION

Possibility of connection new PVP depends on (among others) the voltage change in the connection point (i.e. point of delivery), where is important character of network and type of load. Generally, the possibility to connect new power plants in terms of voltage change is less in the loaded network than in an unloaded network. The most important criterion is the network configuration, so its performance to the connection point. It should be noted that the low voltage networks are the most diverse in terms of the dimension of distribution lines. Connection of new PVP must not exceed next values:

- Maximum permissible voltage change caused by connection of new PVP is 3 % of rated voltage in the low-voltage networks.
- Tolerance of maximum size of low-voltage network is 440 V (phase to phase voltage).

Note, that the values are valid in the Czech Republic.

The following examples used the program E-vlivy of company EnerGoConsult ČB s.r.o. Since this program is considered a 3-phase model, voltage change caused by connecting a single or two-phase power plant is higher. This is reflected by the recommendations in [2] the following prescription:

- Modelling of single-phase power plants in the three-phase computer system with 5 times more power.
- Modelling of two-phase power plants in the three-phase computer system with 1.7 times more power.

2.1. Problem definition

Modelled low-voltage network in Figure 1 is an example of a simple computing of connectivity to one PVP with three-phase power of 10 kW. The important parameter is the extent of network from the distribution transformer to the solution of photovoltaic power plant. This is easy to get from the technical and graphic information systems. However LV network have to be modelled with the power node on the surface of HV network. Equivalent of HV network is specified by a three-phase short circuit apparent power (or current) required to calculate the short-circuit conditions in the high voltage network. We can consider as a simplification the standard value for the average HV distribution network such as 1.1 kA.

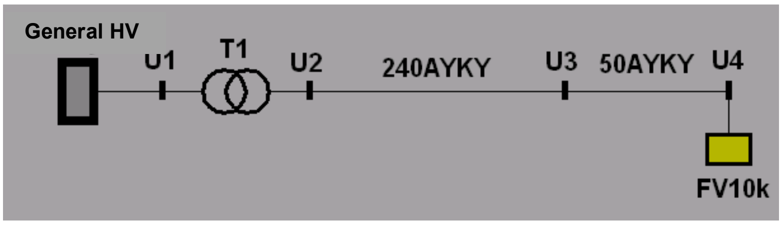

Figure 1 – The simple computing of connectivity to one PVP

If there is other PVP, which may increase voltage at the computed connection point, we have to compute a voltage increase caused by this source. This is shown in the figure 2. In the same way, it is recommended to respect power plant with important power installed in the same network.

Figure 2 – The simple computing of connectivity to two PVP

LV network is not necessary to model with the load as shown in the following figure, which illustrates the voltage change by connecting a single PVP with power 16 kW at the distance of 200 to 1200 meters from the distribution transformer with decreasing dimension of supply lines.

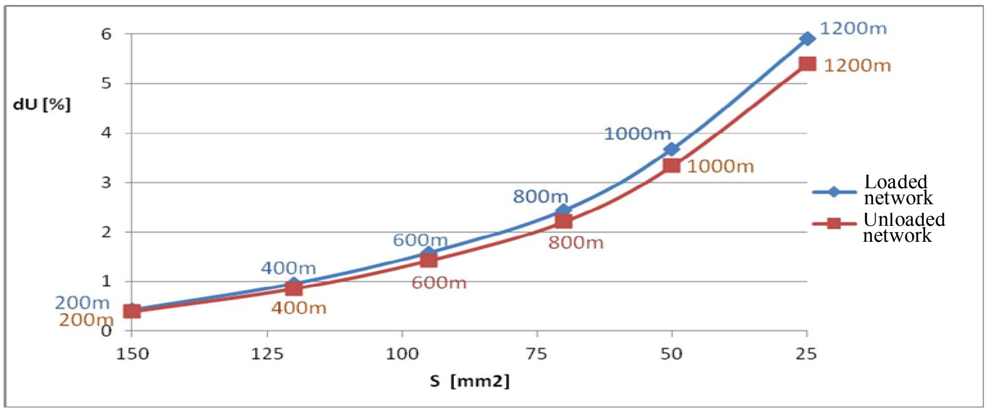

Figure 3 – The voltage change by connecting a single PVP in a loaded and unloaded network

We can see that the voltage change is slightly lower for PVP connected to an unloaded network than the loaded network. And that is why we can neglect the loads in the model.

2.2. *Tested model*

The examples of calculations above are not so much simplified assessment of connectivity new PVP. Let us consider the voltage change caused by one or more PVP as an essential restrictive rule. While respecting variety of LV network we can obtain diagrams, which shows the possibility of connection of new PVP depending on the short-circuit power in LV network and the power of one or more PVP. Figure 4 illustrates tested model for simulation.

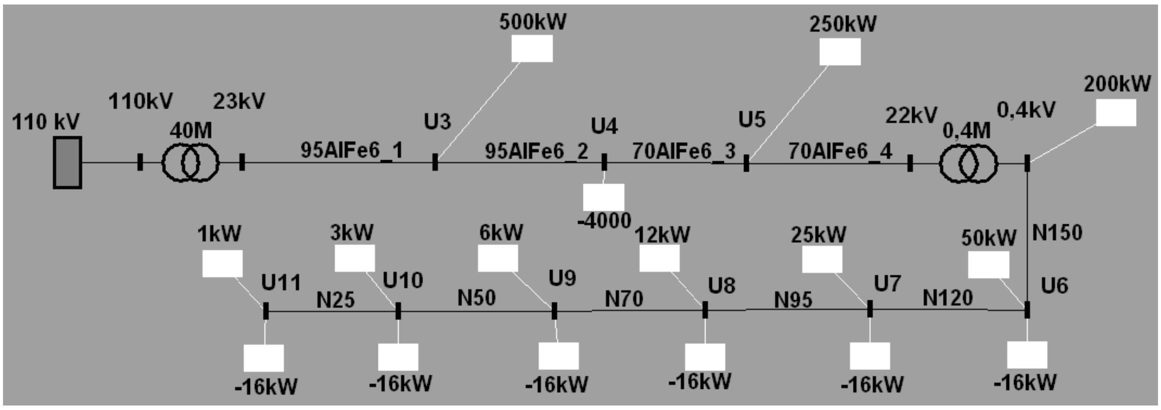

Figure 4 – Tested model

We can see that the dimension of distribution line and the loads increase from the distribution transformer to the end of line. It has been described that parameters of HV network are not important.

2.3. *Simulation results*

Next diagrams show the possibility of connection one or more PVP with power:

3-phase	**2-phase**	**1-phase**	
10 kW	5.8 kW	2 kW	(Figure 5)
16 kW	9.2 kW	3.2 kW	(Figure 6)
21 kW	12 kW	4.2 kW	(Figure 7)

The three-phase short circuit apparent power is represented by equivalent short circuit impedance (Z_k) for each connection point. TS mean a transformer station.

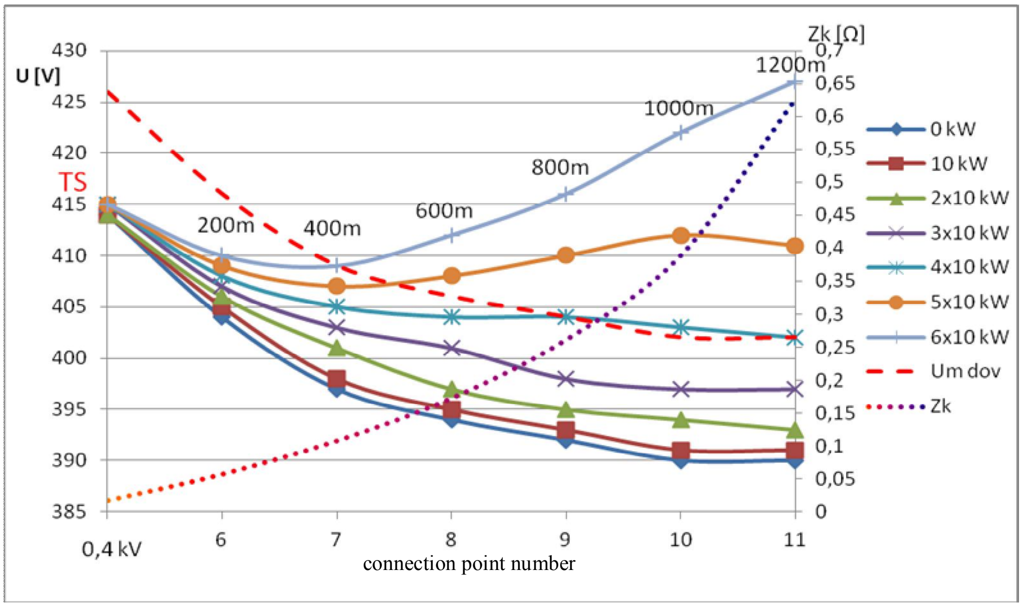

Figure 5 – Possibility of connection one or more PVP 10 kW

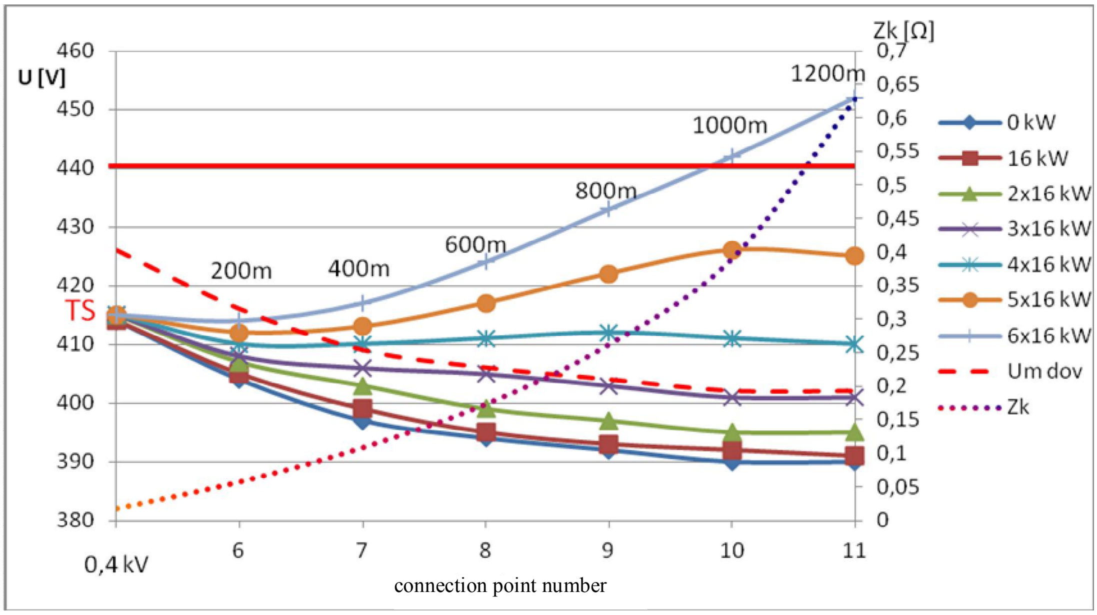

Figure 6 – Possibility of connection one or more PVP 16 kW

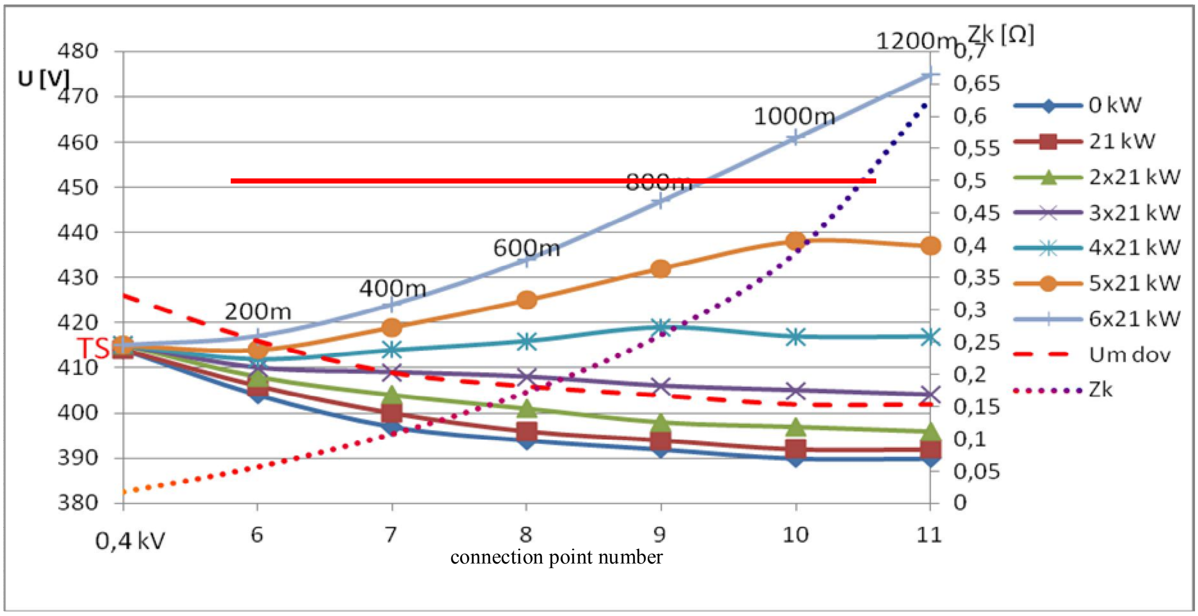

Figure 7 – Possibility of connection one or more PVP 21 kW

Figure 5, 6, 7 – LEGEND: The possibility of connection new PVP increases with their power, distance from distribution transformer and with number of other PVP installed in the same network. Everything depends on the equivalent short circuit impedance.

3. CONCLUSIONS

Practical application of this method is suitable to use there is not a lot of different dimension of distribution lines. In case a dimension (for example 150 mm^2) is used in a larger part of the LV network, it is possible these diagrams create for only this dimension and then we can obtain decision of connectivity possibilities according to the distances from the distribution transformer. So the only local knowledge of an assessing person would suffice to the final assessment. Information about other PVP on the same network is very important.

The simplified calculation is only possible in the certain assumptions contained in this document. In cases with an uncertain result, I recommend to a clear assessment to create a simple model. Further specification can be by specifying the exact short-circuit conditions in the HV network or by entering the real loads to the model or to make accurate measurements in the last case.

REFERENCES

[1] Podmínky provozování distribučních soustav, Příloha č. 4, (*The Czech Republic Law*)

[2] Tesařová, M., Jiřička, J.: Posouzení změn napětí způsobených jednofázovými a dvoufázovými zdroji připojovanými do sítě NN, Sborník konference EPE 2012, ISBN 978-80-214-4514-7

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